AD-A060 196 NAVY UNDERWATER SOUND LAB NEW LONDON CONN F/G 20/1
RANGE VERSUS TIME CALCULATION FOR EARS CRUISE I.(U)
JUN 67 A C VASILOFF
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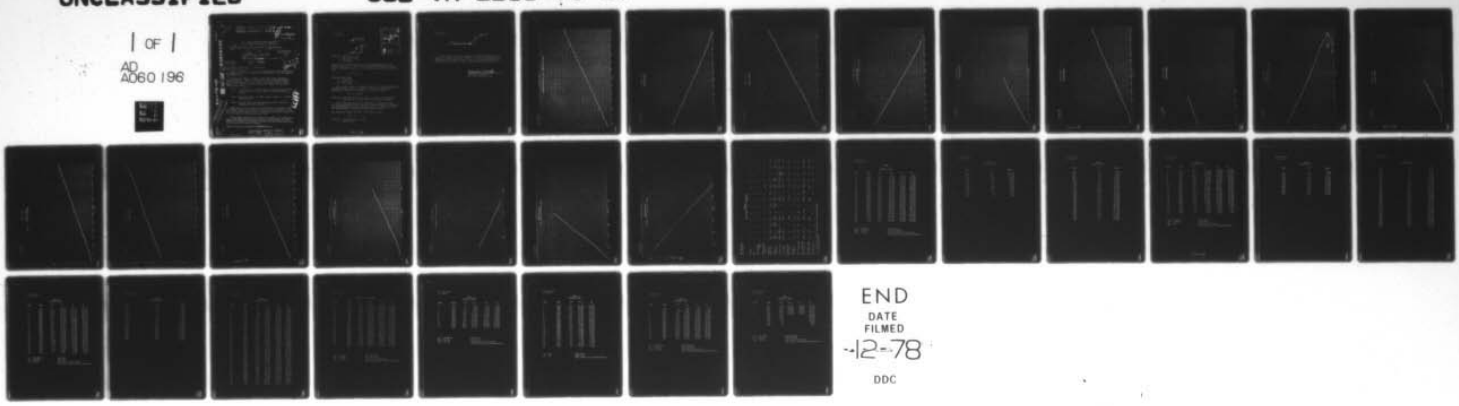

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FORT TRUMBULL, NEW LONDON, CONNECTICUT

RANGE VERSUS TIME CALCULATION FOR EARS CRUISE I.

by

Alexander C. Vasiloff*

USL Problem No. 7-1-401-00-00

USL Technical Memorandum No. 2211-70-67

12 June 1967

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INTRODUCTION

This is a second in a series of memoranda dealing with the gathering and reduction of data collected during "EARS" Cruise I from 28 October to 13 December 1966.

Programs for analysis of EARS I cruise data require continuous range information. Range data gathered is based on skipped projector pulse time and detonation times of explosive charges fired at various depths. The acoustic signals used during the several runs fall into three general cases.

Case 1 - CW pulse only -10 milliseconds, 100 milliseconds, and 1000 milliseconds long; either 1900 Hz and 3800 Hz mixed, or 400 Hz.

Case 2 - Explosive charges only, MK54, MK59-1, MK61-0 or 1 lb TNT blocks w/fuses.

Case 3 - Both CW Pulses and explosive charges with no projector skipped pulse times available.

Range data for case 1 signals are the simplest to calculate. Using the skipped projector pulse time as a reference, the projector to hydrophone travel time of the CW signal is measured and multiplied by C_s; where C_s is the average horizontal velocity of sound.

Case 2 signal ranges require additional information for calculation. Ship's speed taken from ship's log, detonation depth (preset by fuses, either set or pressure actuated) and observed sink times yield slant range from the ship to the explosive charge.

*AVCO, Cincinnati, Contract No: N140(70024)78657B

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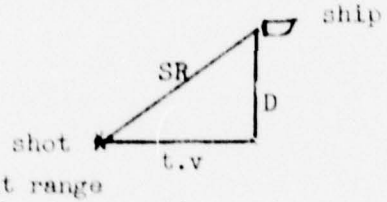
$$SR = \sqrt{D^2 + (t.v)^2}$$



where SR = slant range
D = depth of detonation
t = observed sink time
v - ships speed

When the shot is heard through the hull mounted hydrophone, it has already travelled SR. Travel time is measured from this time to when it is received by a hydrophone on the receiving ship. The shot range is then:

$$R_s = T.C_s + SR$$

where R_s = shot range
T = travel time
C_s = sound velocity
SR = slant range

Case 3 signals, where no skipped projector pulse times are available, require both shot and projector range calculations. Shot range is determined by the method explained above. Projector range is:

$$Rp = Rs + (Rsp)$$

where Rsp = range from projector to shot. The sign of Rsp is positive when range is closing, negative when range is opening.

Rsp is found by taking the time difference of arrival from the hull mounted hydrophone and the projector mounted hydrophone. The signals from these phones are fed into separate channels of a Sanborn recorder. The time difference is read directly from the chart with

when projector receives the signal before the hull does.

$$R_{sp} = SR + \quad t \ .cs$$

where Δt = time difference of arrival
cs= sound velocity

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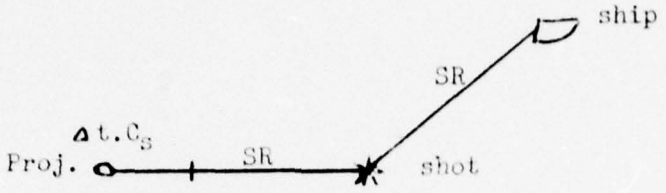

Table 1 summarizes all run parameters and figure references for range vs time plots. Figures 1 through 13 are the range time plots for the stations of the EARS I Cruise. Tables 2 through 14 summarize travel time and range calculations used in generating the Range time plots.

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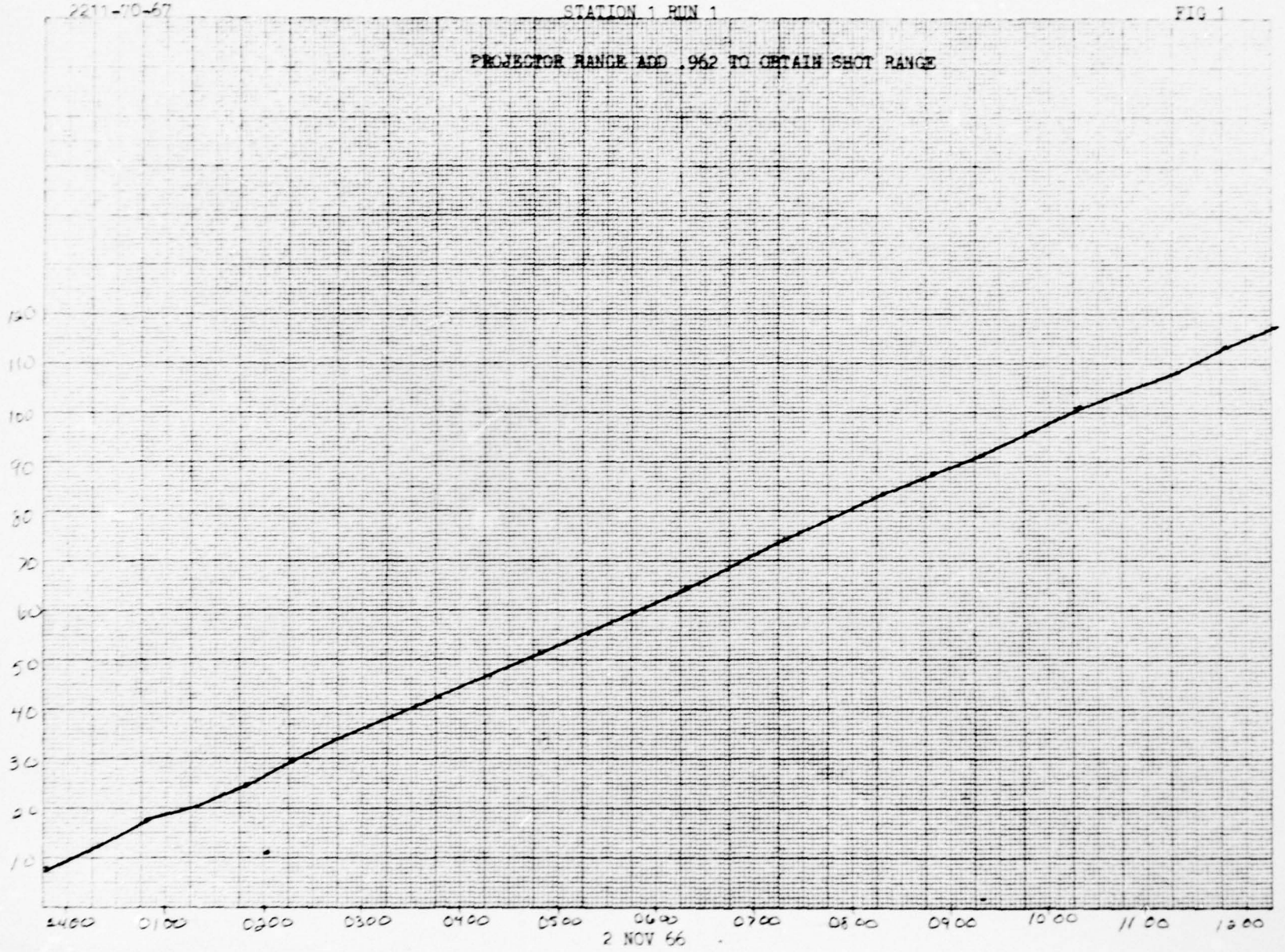
USL Tech Memo
2211-70-67

STATION 1 RUN 1

FIG 1

PROJECTOR RANGE ADD .962 TO OBTAIN SHOT RANGE



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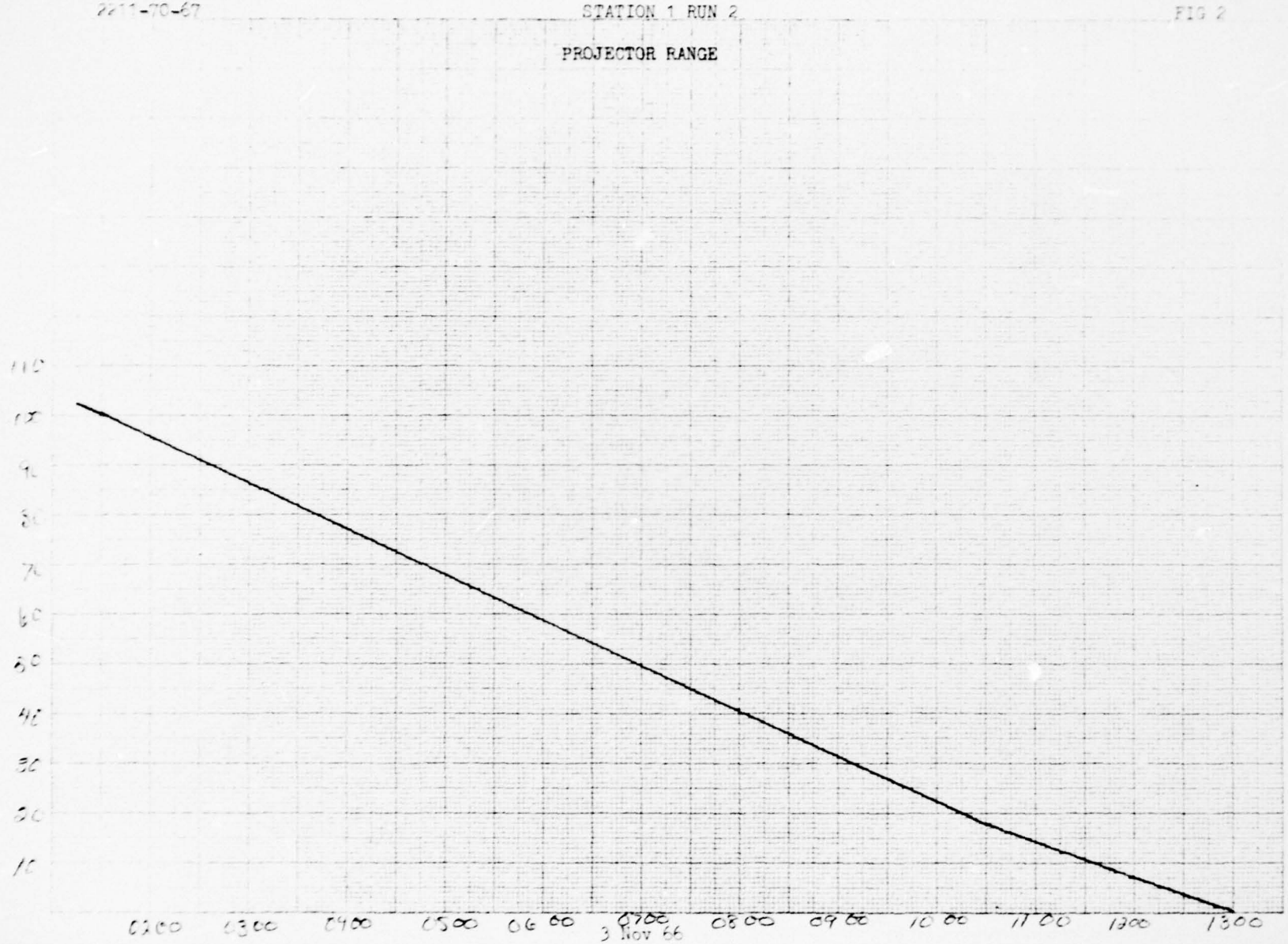
STATION 1 RUN 2

FIG 2

PROJECTOR RANGE



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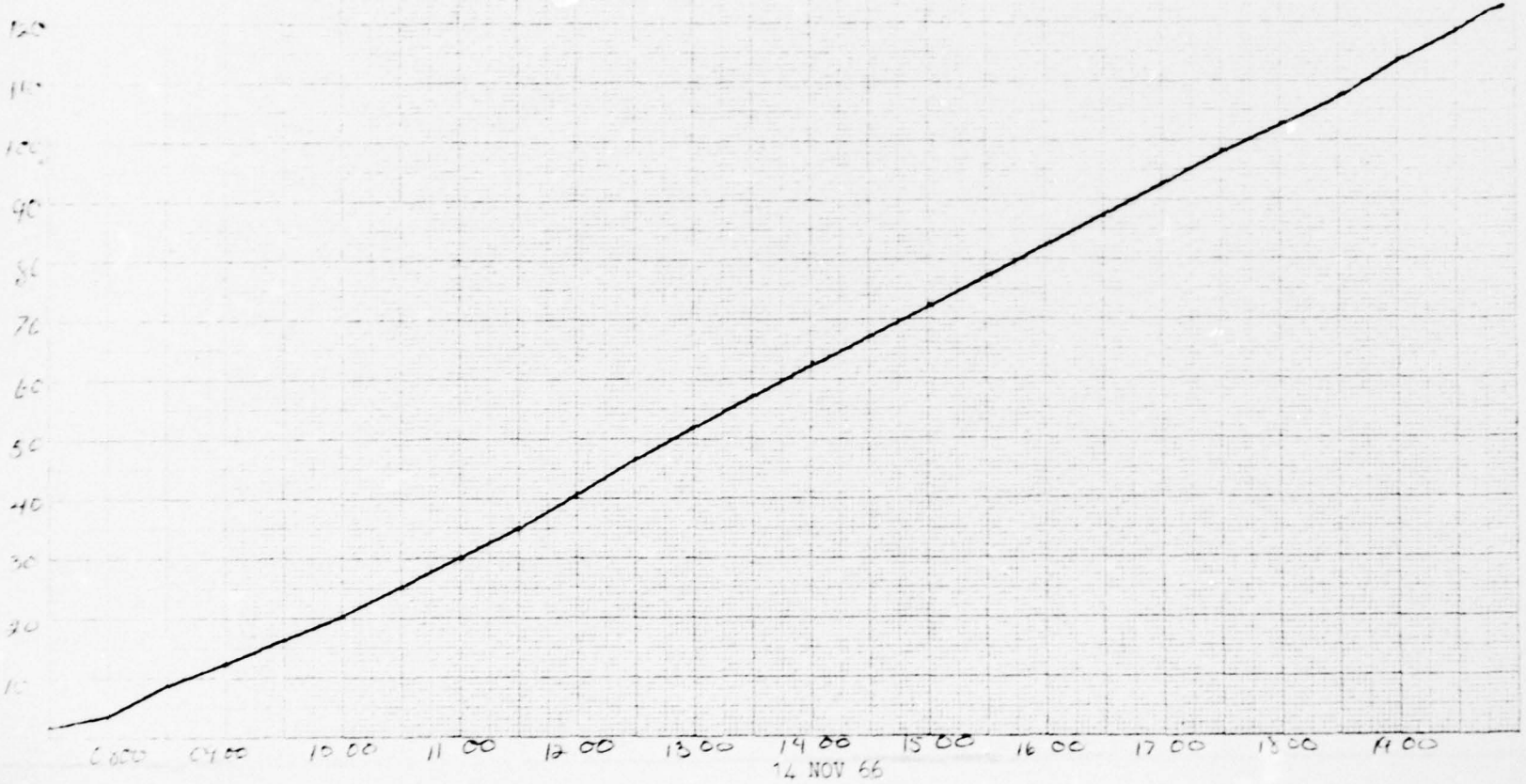
STATION 3 RUN 1

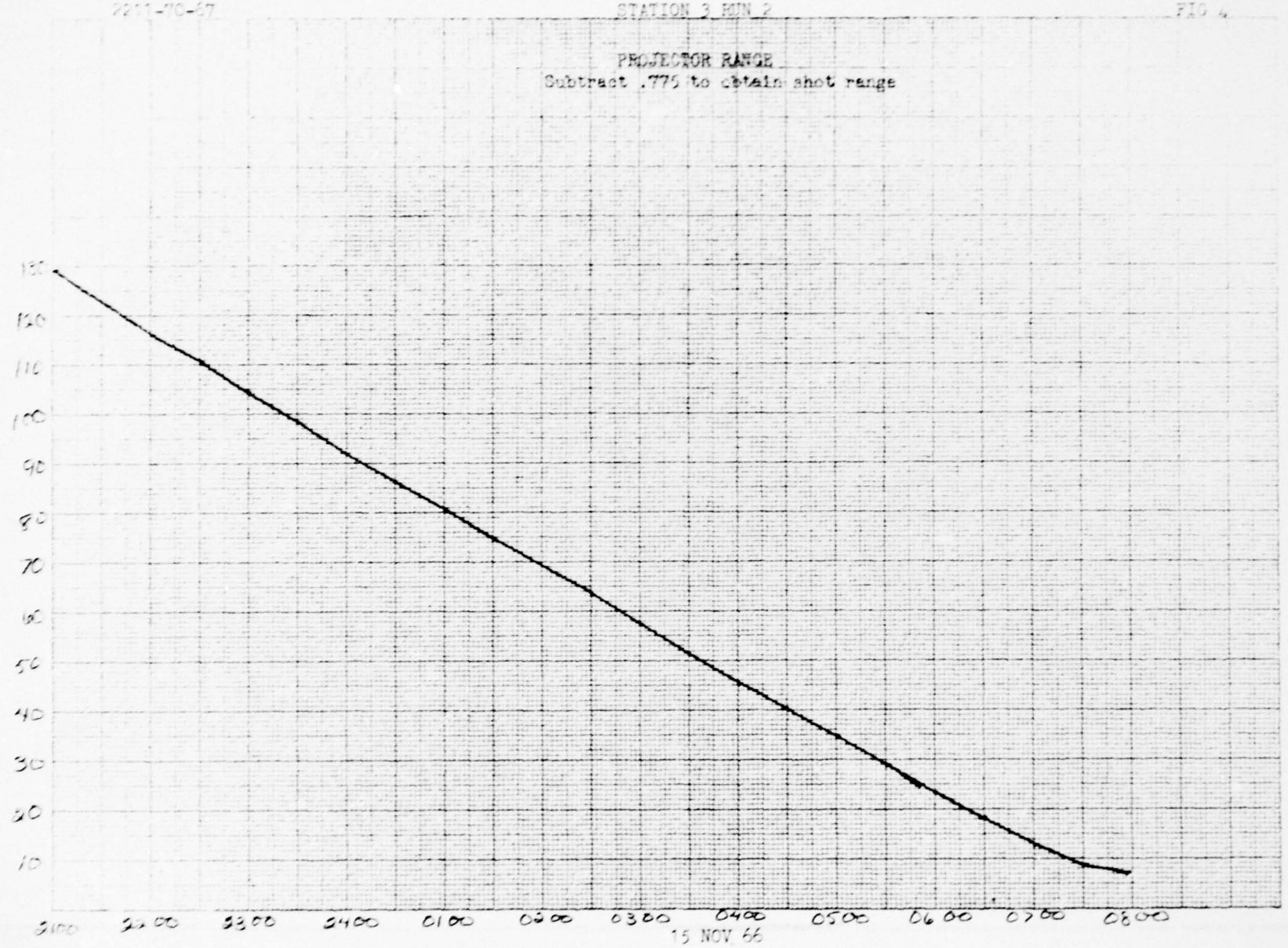
FIG 3

PROJECTOR RANGE



STATION 3 RUN 2

FIG 4



USL TECH MEMO
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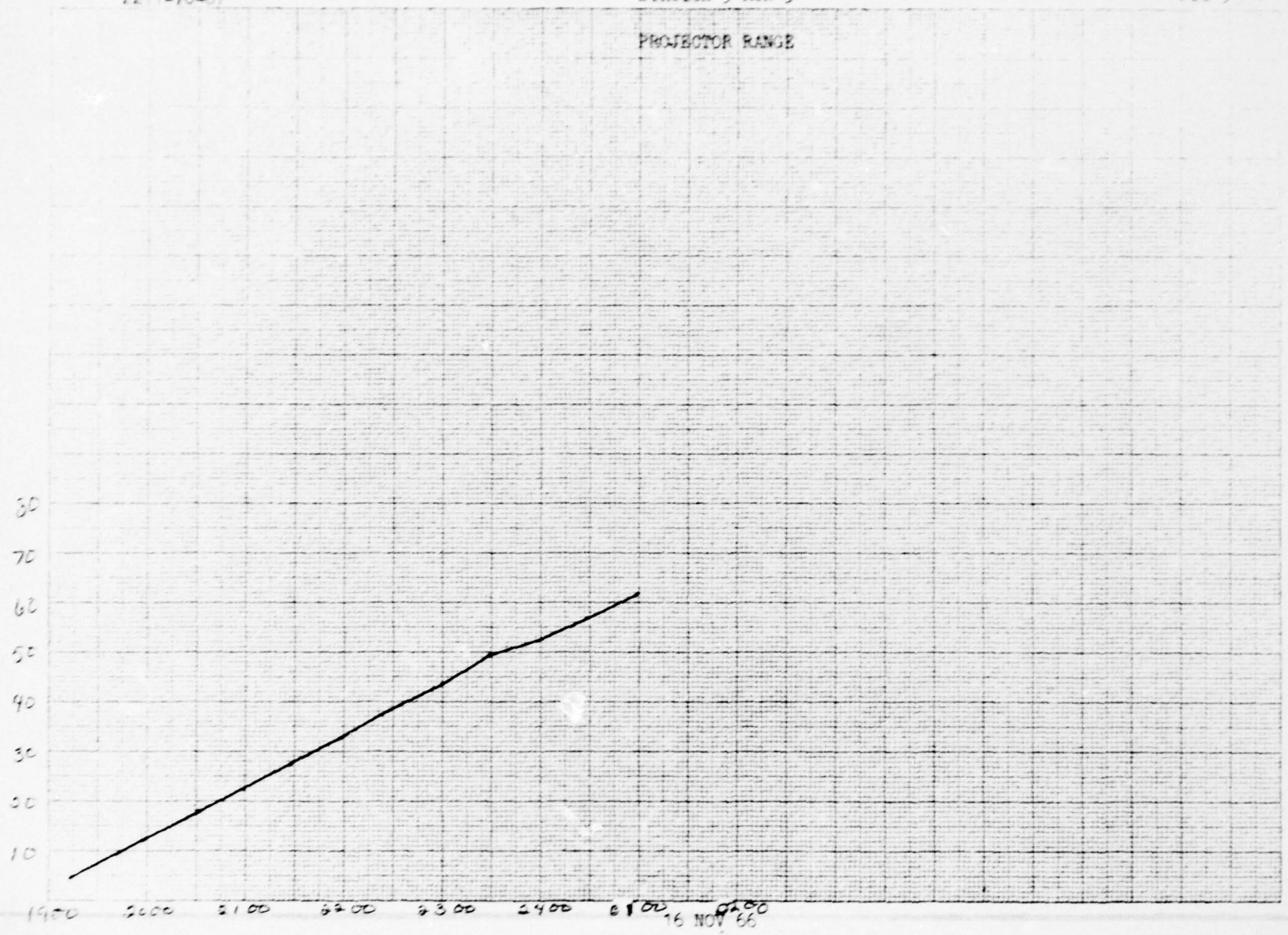
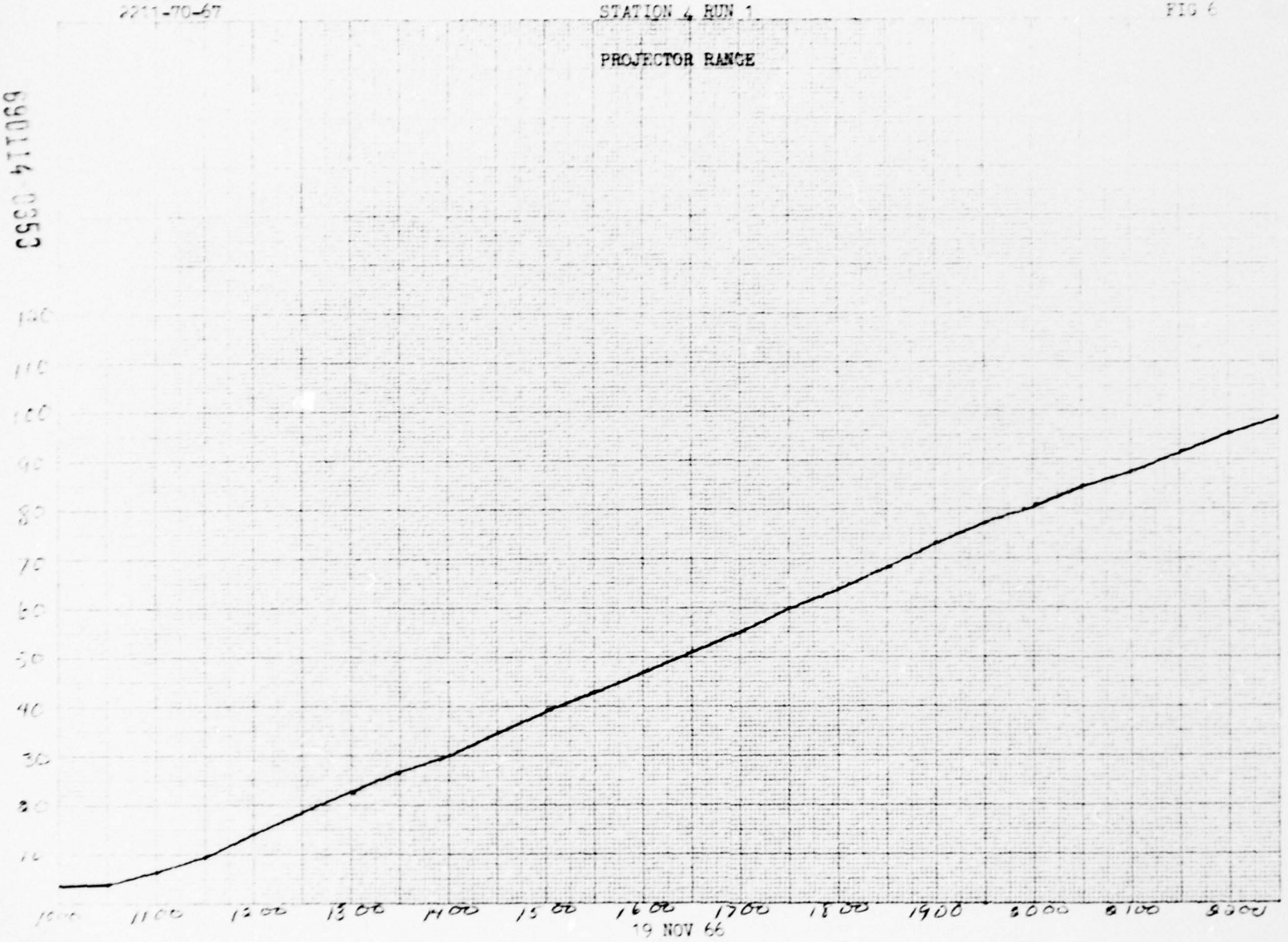
STATION 3 RUN 3

FIG 5



STATION 4 RUN 1

FIG 6



USL TECH MEMO
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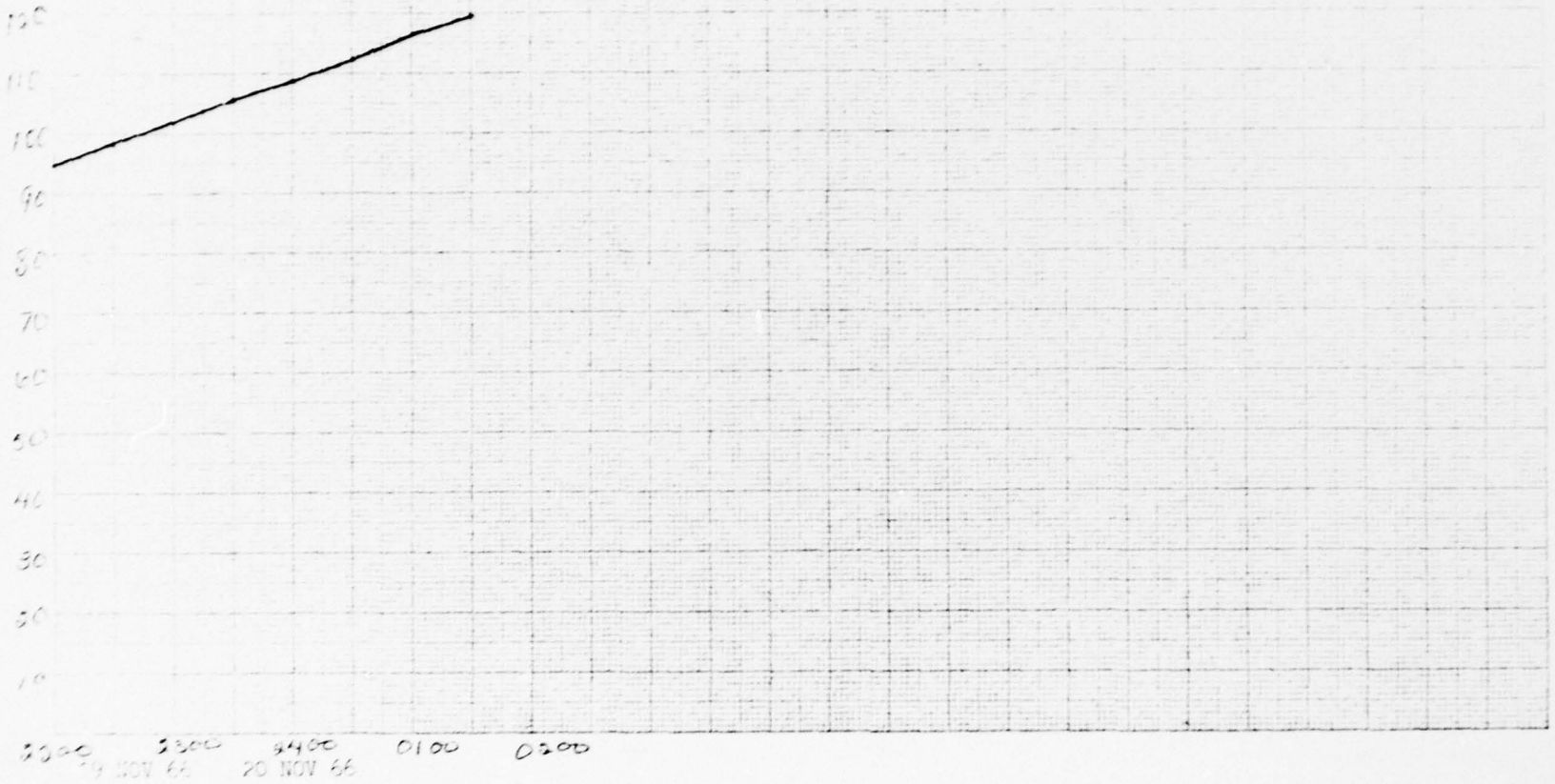
STATION 4 RUN 1

FIG 6(a)

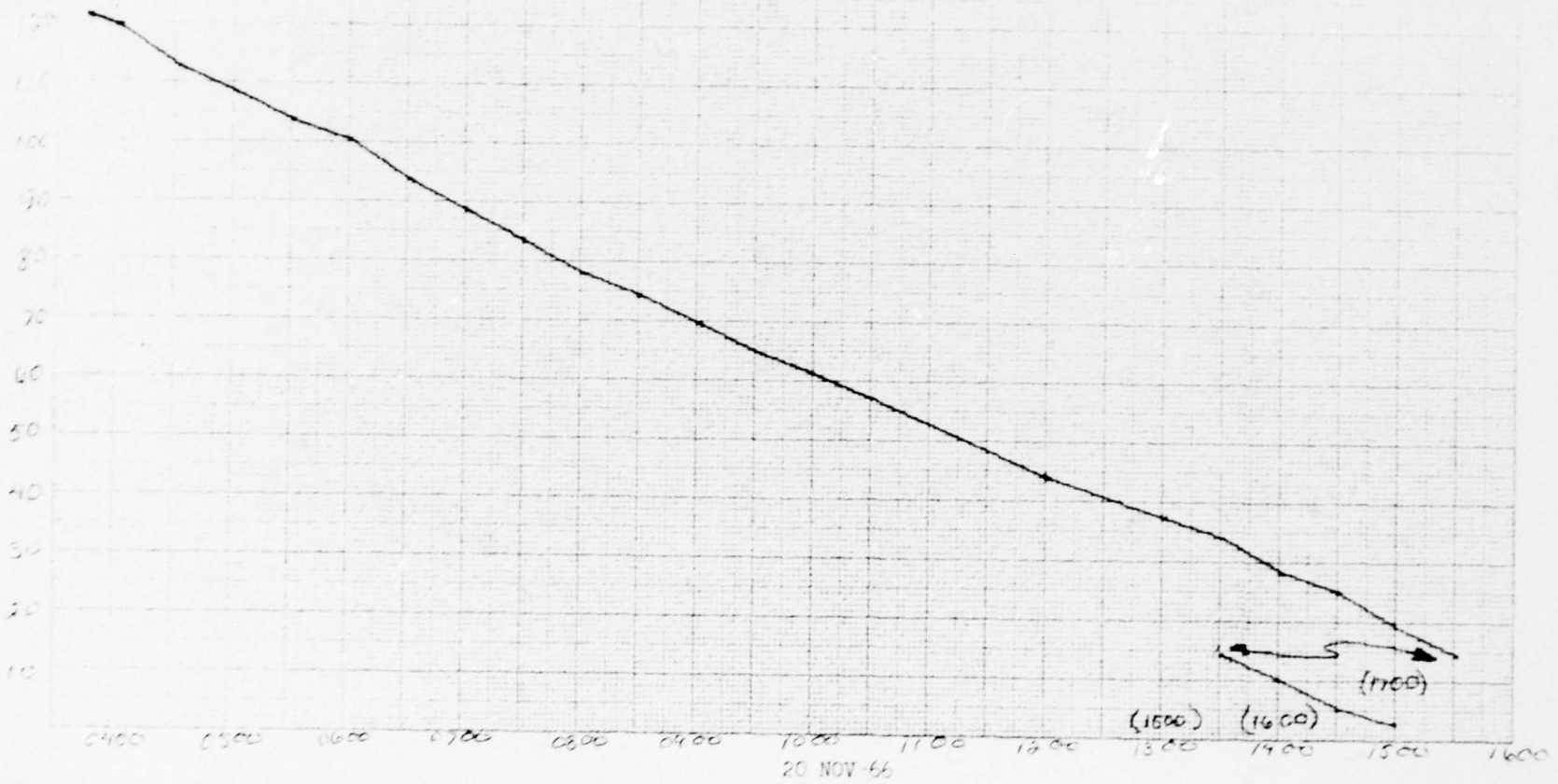
PROJECTOR RANGE



STATION 4 RUN 2

FIG 7

PROJECTOR RANGE
Subtract .590 to obtain shot range



STATION 4 RUN 3

PROJECTOR RANGE

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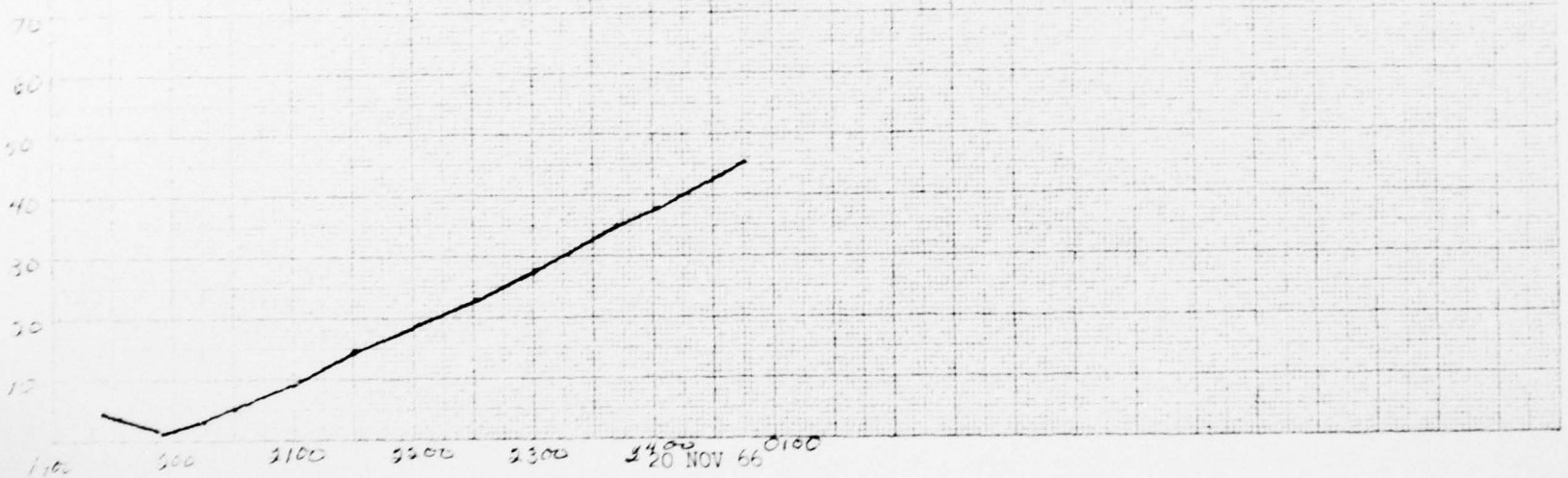

USL TE/H MEMO
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STATION 5 RUN 1

FIG 7

PROJECTOR RANGE
Add 2.617 to obtain shot range

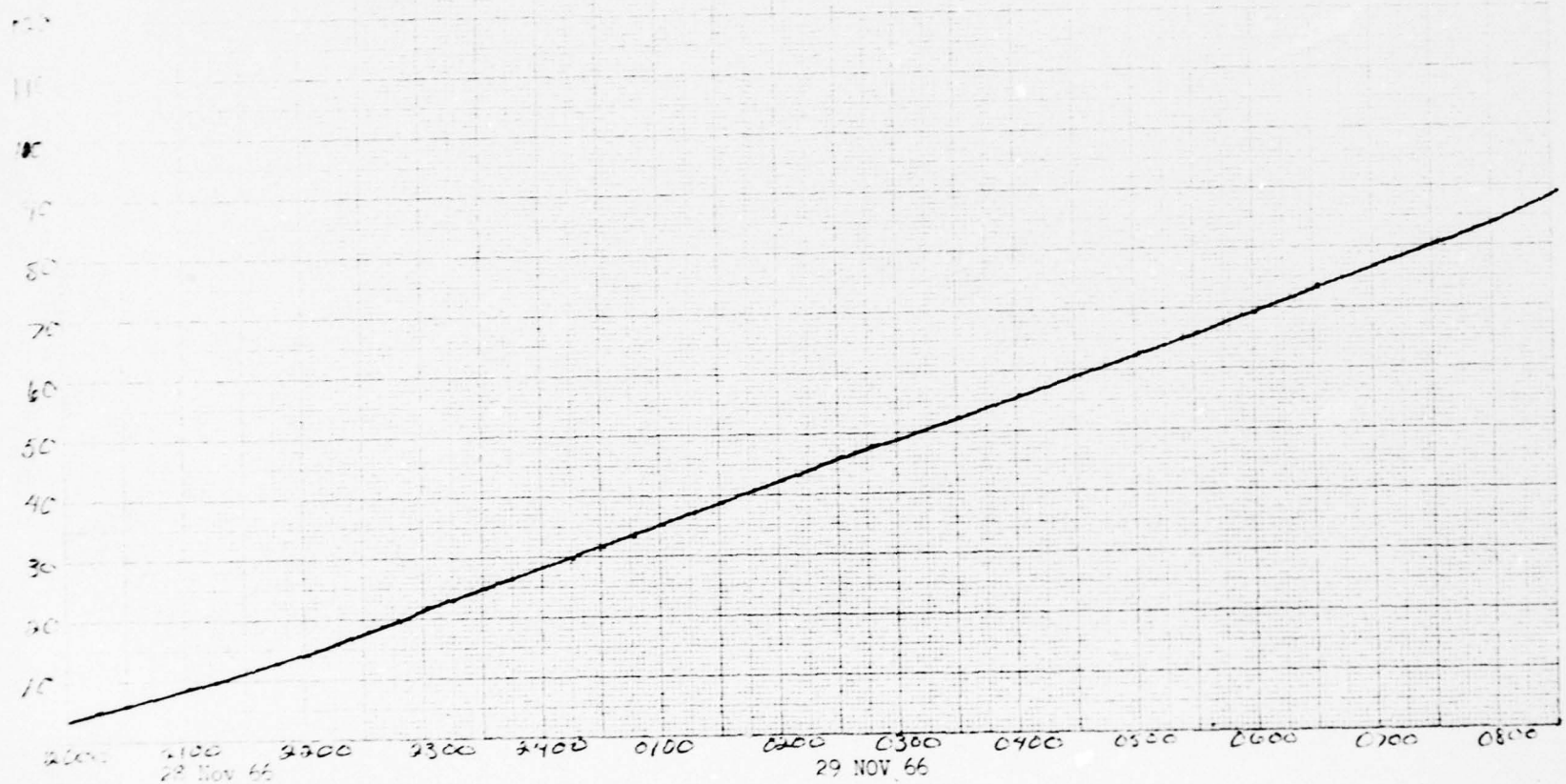
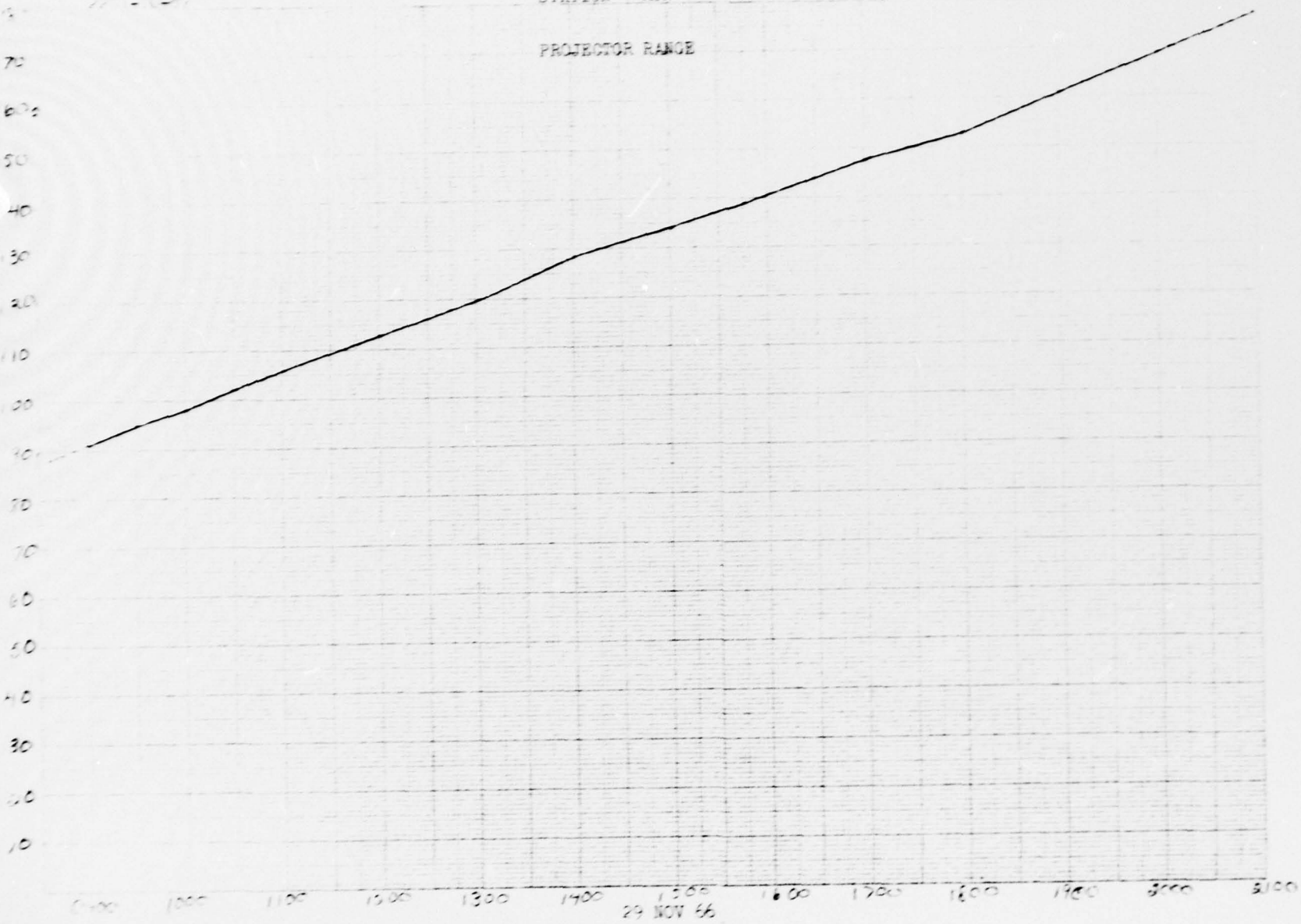


FIG 9(a)

STATION 1 RUN 1

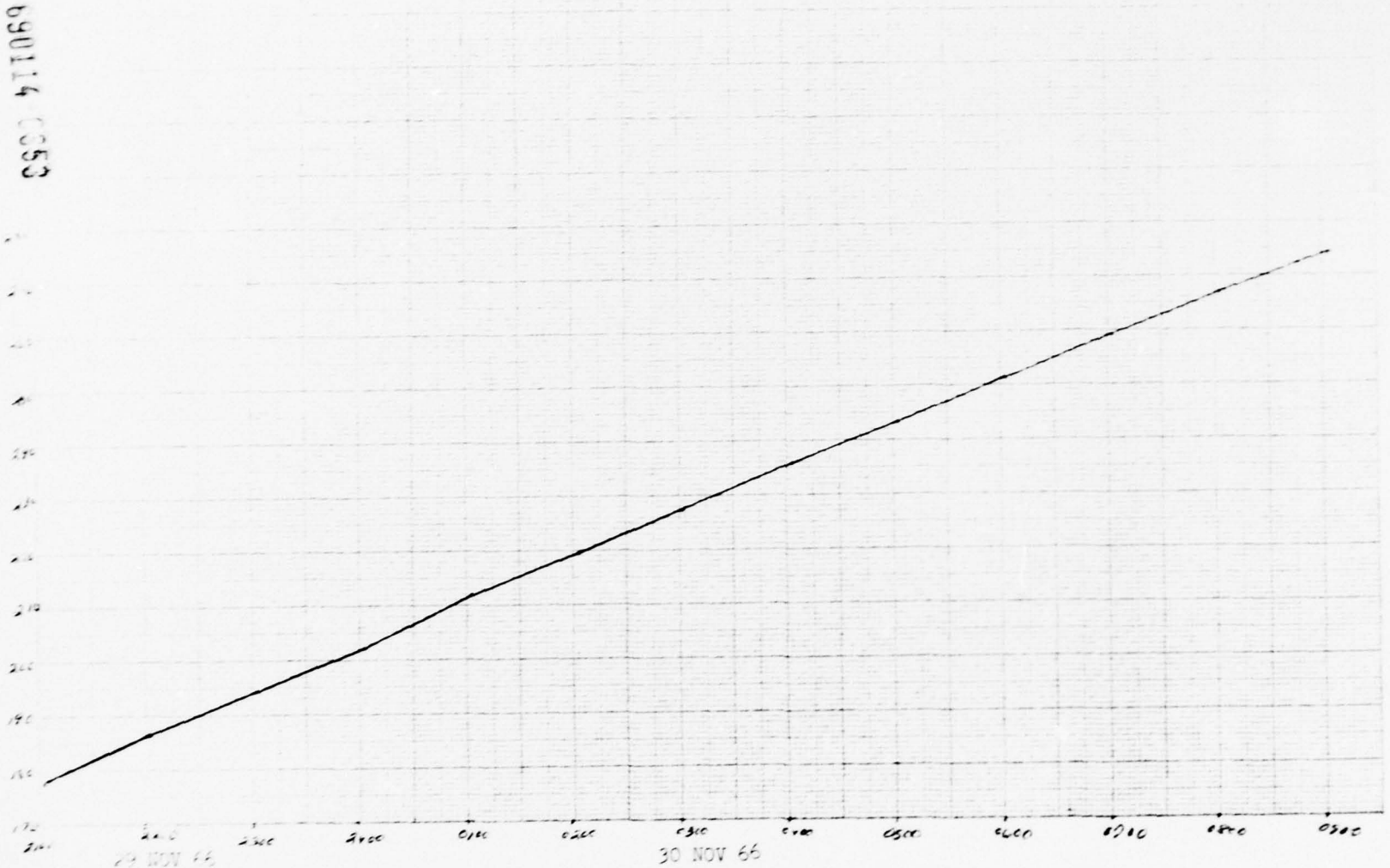
PROJECTOR RANGE



STATION 5 RUN 1

FIG 9(b)

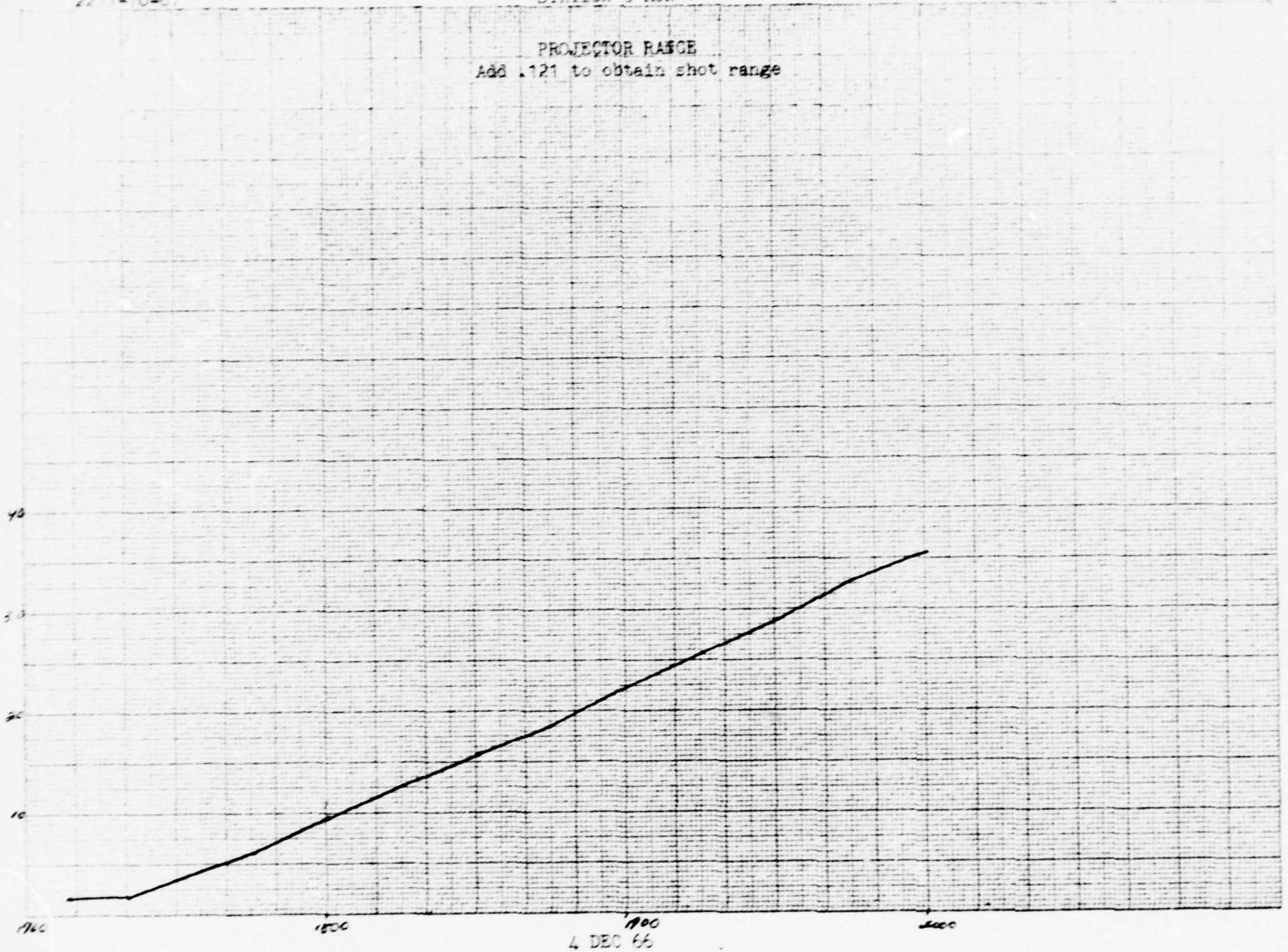
PROJECTOR RANGE



STATION 6 RUN 1

FIG 10

PROJECTOR RANGE
Add .121 to obtain shot range



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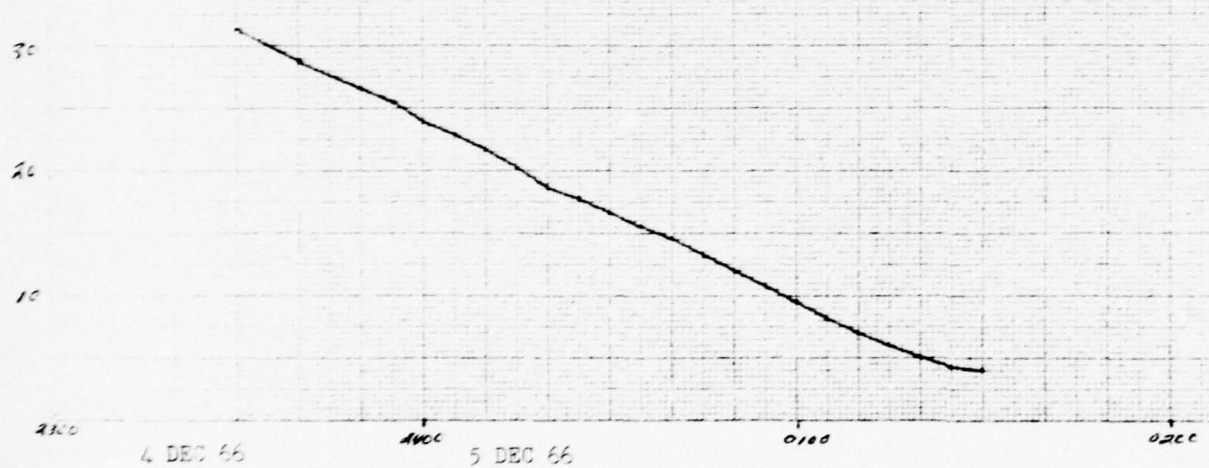
STATION 6 RUN 2

FIG 11

Shot Range - No pulses this run



USL TECH MEMO
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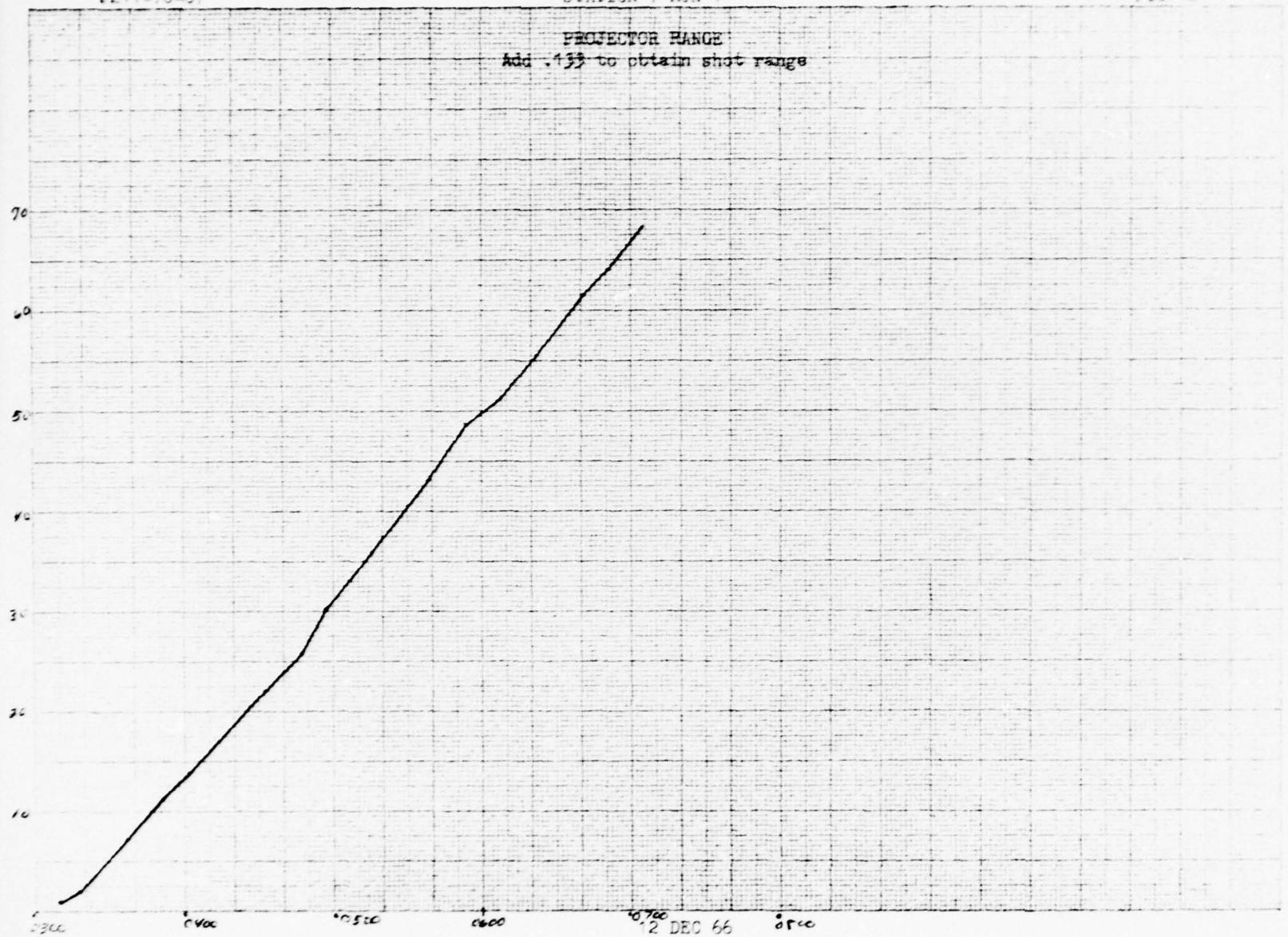
STATION 7 RUN 1

FIG 12



STATION 7 RUN 2

FIG 13

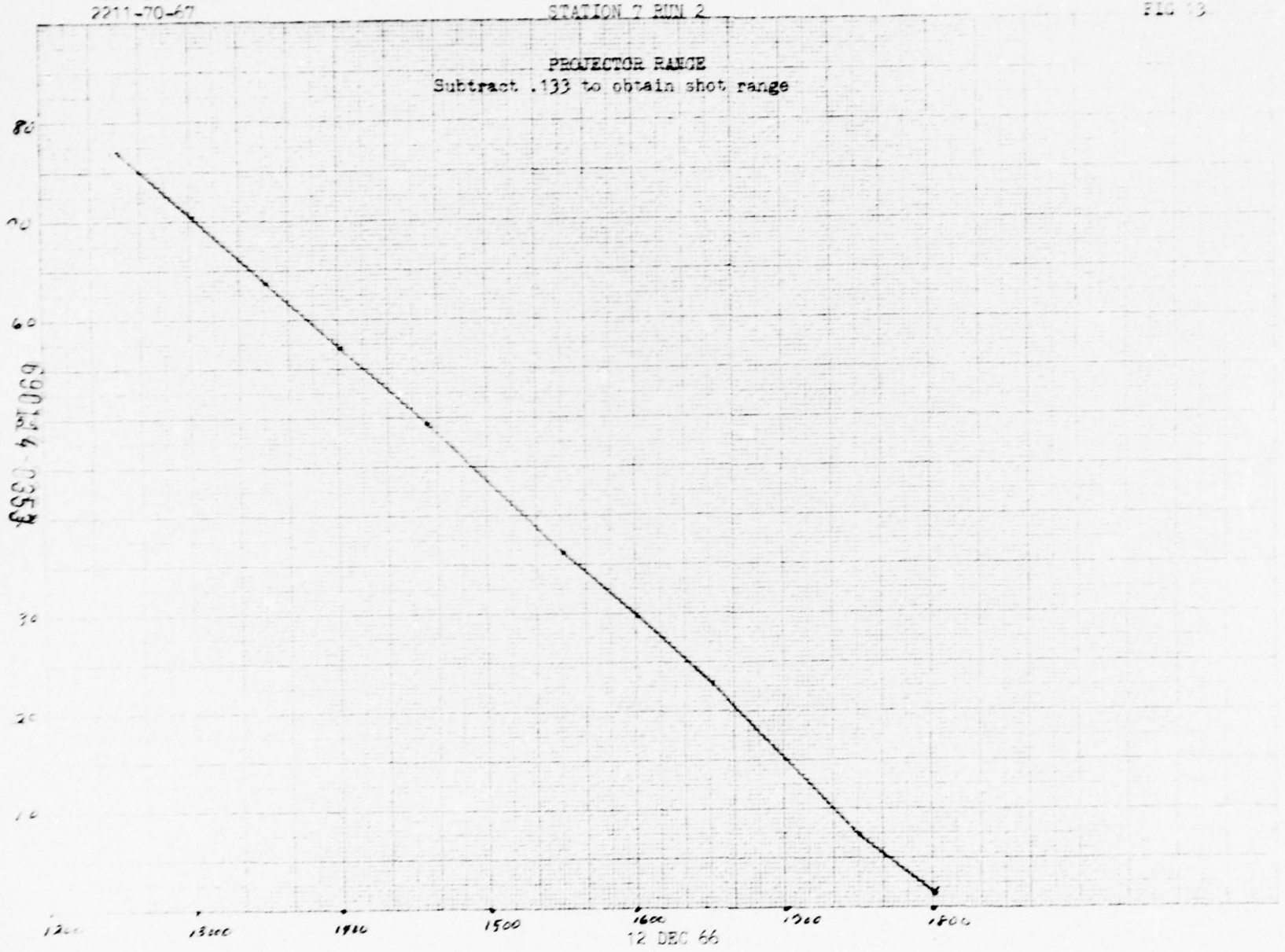


TABLE 1
EARS CRUISE I RUN PARAMETERS

Station	1	1	3	3	3	4	4	4	5	6	6	7	7
Run	1	2	1	2	3	1	2	3	1	1	2	1	2
Type O-open C-close	O	C	O	C	O	O	C	O	O	O	C	O	C
Ship's speed (knots)	5	5	5	5	5	4	3.7	5	3.65	7	7	7	7
Projector Depth (ft)	800	800	2500	900	900	4000	900	900	4000	60	60	200	200
Projector Frequency	1900 3800	400	1900 3800	1900 3800	400	1900 3800	1900 3800	400	1900 3800	1900 3800	400	1900 3800	400
Charge type	MK61-0	MK61-0	-	MK59-1	-	-	MK59-1	-	MK59-1	MK61-0	MK61-0 MK54	TNT*	TNT*
Shot Depth	800'	800'	-	2500'	-	-	4000'	-	4000'	60'	60'	200'	200'
Charge Sink Time (sec)	51	51	-	94.82	-	-	147.26	-	147.3	6**	6**	89	89
Sink Rate (ft/sec)	15.9	15.9	-	26.3	-	-	27.2	-	27.2	10	10	2.1	2.1
Max. Range(kyds)	118	102	121	128	62	119	122	45	273	36	31	67	77
Proj. Dist. Behind ship (ft)	3305	3305	-	3125	3125	-	2678	3125	8758	424	424	1451	1451
Shot Dist. Behind Ship (ft)	420	420	-	800	-	-	907	-	907	71	71	1051	1051
Range/Time Fig.	1	2	3	4	5	6	7	8	9	10	11	12	13

* 1 lb TNT Block with 42" fuse held 10 sec before thrown
**Estimated sink time

TABLE 2

STATION 1 RUN 1

ITEM	TIME	T/T	TC_s	R_s	R_p
2	2346	5.4	8.749	9.052	8.090
3	0016	8.3	13.446	13.749	12.787
4	0046	11.8	19.116	19.419	18.457
5	0117	13.4	21.708	22.011	21.049
6	0146	15.9	25.758	26.061	25.099
7	0216	19.1	30.942	31.245	30.283
8	0246	21.9	35.478	35.781	34.819
9	0316	24.4	39.528	39.831	38.869
10	0346	26.9	43.578	43.881	42.919
11	0416	29.7	48.114	48.417	47.455
12	0446	32.5	52.650	52.953	51.991
13	0516	35.0	56.700	57.003	56.041
14	0546	37.7	61.074	61.377	60.415
15	0616	40.5	65.610	65.913	64.951
17	0716	46.7	75.654	75.957	74.995
18	0746	49.4	80.028	80.331	79.369
19	0816	52.7	85.374	85.677	84.715
20	0846	54.8	88.776	89.079	88.117
21	0916	57.5	93.150	93.453	92.491
22	0946	60.1	97.362	97.665	96.703
23	1016	62.8	101.736	102.039	101.077
24	1046	65.2	105.624	105.927	104.965
25	1116	67.8	109.836	110.139	109.177
26	1147	70.7	114.534	114.837	113.875
27	1217	73.3	118.746	119.049	118.070

C_s = 1.62 Ky/sec
SR = .303 Ky
R_{sp} = .962 Ky

Shot 800 ft.
Projector 800 ft.
Projector 2885 ft aft of shot
Shot travels 909 ft before detection

TABLE 3
STATION 1 RUN 2

TIME	T/T	RANGE
0015	63.4	102.708
0031	62.1	100.602
1030	11.15	18.063
1045	10.14	16.427
1115	7.92	12.830
1130	6.7	10.854
1145	5.6	9.072
1200	4.68	7.582
1215	3.6	5.832
1230	2.5	4.050
1250	.8	1.296
1257	.44	.713
1300	.3	.486

TABLE 4
STATION 3 RUN 1

TIME	T/T	RANGE
728	1.2	1.944
801	2.0	3.240
834	5.0	8.100
900	7.3	11.826
930	9.8	15.876
1000	12.2	19.764
1030	15.2	24.624
1100	18.3	29.646
1130	21.4	34.668
1200	24.6	39.852
1230	28.8	46.656
1300	31.9	51.678
1330	35.1	56.862
1400	38.6	62.532
1430	41.4	67.068
1500	44.5	72.090
1530	47.5	76.950
1600	50.6	81.972
1630	53.6	86.832
1700	57.0	92.340
1730	60.4	97.848
1800	63.1	102.222
1830	66.3	107.406
1900	69.8	113.076
1930	72.8	117.936
1945	74.6	120.852
1953	75.2	121.824

TABLE 5
STATION 3 RUN 2

ITEM	TIME	T/T	TC_S	R_S	R_P
1	2102	78.6	127.332	128.205	128.980
3	2201	70.9	114.858	115.731	116.506
4	2231	67.3	109.026	109.899	110.674
5	2301	63.4	102.708	103.581	104.356
6	2331	59.6	96.552	97.425	98.200
7	2401	55.6	90.072	90.945	91.720
8	0031	52.4	84.888	85.761	86.536
9	0101	48.6	78.732	79.605	80.380
10	0131	45.2	73.224	74.097	74.872
11	0201	41.7	67.554	68.427	69.202
12	0231	38.1	61.722	62.595	63.370
13	0301	34.5	55.890	56.763	57.538
14	0331	30.9	50.058	50.931	51.706
15	0401	27.3	44.226	45.099	45.874
16	0431	23.8	38.556	39.429	40.204
17	0501	20.5	33.210	34.083	34.858
18	0531	17.0	27.540	28.413	29.188
19	0601	13.5	21.879	22.743	23.518
20	0631	10.3	16.686	17.559	18.334
21	0701	7.0	11.340	12.213	12.988
22	0731	4.4	7.128	8.001	8.776
23	0755	3.7	5.994	6.867	7.642
24	0756	3.3	5.346	6.219	6.994
25	0757	3.5	5.670	6.543	7.318

C_S = 1.62 Ky/sec
SR = .873 Ky
R_{SP}= .775

Shot 2500 ft
Proj 900 ft
Proj 2325 aft of shot
Shot travels 2619 ft before detection

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TABLE 6
STATION 1 RUN 1

TIME	T/T	RANGE
1915	3.0	4.860
1945	6.0	9.720
2000	7.5	12.150
2033	11.2	18.144
2100	13.8	22.356
2130	16.8	27.216
2200	20.3	32.886
2230	24.0	38.880
2300	27.0	43.740
2330	30.8	49.896
2400	32.3	52.326
0030	35.3	57.186
0100	38.3	62.046

TABLE 7
STATION 4 RUN 1

TIME	T/T	RANGE
1000	1.8	2.916
1030	1.9	3.078
1100	3.2	5.184
1130	5.3	8.586
1200	8.2	13.284
1235	11.4	18.468
1300	13.2	21.384
1330	15.8	25.596
1400	18.3	29.646
1431	21.0	34.020
1500	23.5	38.070
1530	26.0	42.120
1600	28.7	46.494
1630	31.3	50.706
1730	33.8	54.756
1800	39.2	63.504
1830	41.8	67.716
1900	44.8	72.576
1930	47.5	76.950
2000	49.7	80.514
2030	52.0	84.240
2100	54.2	87.804
2130	56.4	91.368
2200	58.6	94.932
2230	60.8	98.496
2300	63.0	102.060
2330	65.2	105.624
2400	67.4	109.188
0030	69.6	112.752
0100	72.0	116.640
0130	73.9	119.718

TABLE 8
STATION 4 RUN 2

ITEM	TIME	T/T	T.C_S	R_S	R_P
1	0347	74.1	120.042	121.429	122.019
2	0402	73.2	118.584	119.971	120.560
3	0432	69.0	111.780	113.167	113.757
4	0502	66.2	107.244	108.631	109.221
5	0532	63.0	102.060	103.447	104.037
6	0602	61.2	99.144	100.531	101.121
7	0632	57.1	92.502	93.889	94.479
8	0702	54.0	87.480	88.867	89.457
9	0732	51.0	82.620	84.007	84.597
10	0802	48.1	77.922	79.309	79.899
11	0832	45.1	73.062	74.449	75.039
12	0902	42.1	68.202	69.589	70.179
13	0932	39.5	63.990	65.377	65.967
14	1002	37.0	59.940	61.327	61.917
15	1032	34.3	55.566	56.953	57.543
18	1200	26.2	42.444	43.831	44.421
20	1302	22.1	35.802	37.189	37.779
21	1332	19.84	32.141	33.528	34.118
22	1402	16.40	26.568	27.955	28.545
23	1432	14.42	23.360	24.747	25.337
24	1502	10.8	17.496	18.883	19.473
25	1532	7.9	12.798	14.185	14.775
26	1602	5.05	8.181	9.568	10.158
27	1632	2.1	3.402	4.789	5.379
28	1655	.7	1.134	2.521	3.111

C_S = 1.62 Ky/sec
SR = 1.387 Ky
R_{SP}= .590 Ky

Shot 4000
Proj 900
Proj 1771 ft aft of shot
Shot Travels 4160 ft before detection

TABLE 9
STATION 4 RUN 3

TIME	T/T	RANGE
1925	3.0	4.860
1933	2.3	3.726
1943	1.7	2.754
1951	1.2	1.944
1955	1.1	1.782
2000	1.2	1.944
2015	2.0	3.240
2030	3.3	5.346
2100	5.8	9.396
2130	8.8	14.256
2204	11.8	19.116
2231	14.4	23.328
2300	17.2	27.864
2333	20.5	33.210
2343	21.8	35.316
2400	23.4	37.908
0033	27.0	43.740
0044	27.8	45.036

TABLE 10
STATION 5 RUN 1

ITEM	TIME	T/T	$T.C_s$	R_s	R_p
4	2002	2.7	4.374	5.741	3.124
5	2017	3.6	5.832	7.199	4.582
6	2032	4.4	7.128	8.495	5.878
8	2102	6.05	9.801	11.168	8.551
9	2117	6.65	10.773	12.140	9.523
11	2147	8.6	13.932	15.299	12.682
12	2202	9.4	15.228	16.595	13.978
13	2217	10.5	17.010	18.377	15.760
14	2232	11.7	18.954	20.321	17.704
15	2247	12.8	20.736	22.103	19.486
16	2302	13.8	22.356	23.723	21.106
17	2317	14.9	24.138	25.505	22.888
18	2332	16.0	25.920	27.287	24.670
19	2347	17.0	27.540	28.907	26.290
21	0017	19.1	30.942	32.309	29.692
22	0032	20.1	32.562	33.929	31.312
23	0047	21.3	34.506	35.873	33.256
24	0102	22.3	36.126	37.493	34.876
25	0117	23.5	38.070	39.437	36.820
26	0132	24.5	39.690	41.057	38.440
27	0147	25.7	41.634	43.001	40.384
28	0202	26.7	43.254	44.621	42.004
29	0217	27.9	45.198	46.565	43.948
30	0232	29.0	46.980	48.347	45.730
31	0247	29.9	48.438	49.805	47.188
32	0302	31.0	50.220	51.587	48.970
33	0332	33.0	53.460	54.827	52.210
34	0402	35.1	56.862	58.229	55.612
35	0432	37.1	60.102	61.469	58.852
36	0502	39.3	63.666	65.033	62.416
37	0532	41.5	67.230	68.597	65.980
38	0600	43.3	70.146	71.513	68.896
39	0632	46.0	74.520	75.887	73.270
40	0702	48.1	77.922	79.289	76.672
41	0732	50.4	81.648	83.015	80.398
42	0802	52.6	85.212	86.579	83.962
44	0838	55.5	89.910	91.277	88.660
45	0902	57.3	92.826	94.193	91.576
46	0932	59.6	96.552	97.919	95.302
47	1002	61.8	100.116	101.483	98.866
48	1032	64.2	104.004	105.371	102.754
49	1102	66.3	107.406	108.773	106.156

TABLE 10 (continued)

ITEM	TIME	T/T	$T.C_S$	R_S	R_P
50	1202	70.8	114.696	116.063	113.446
51	1302	75.2	121.824	123.191	120.574
52	1402	79.8	129.276	130.643	128.026
53	1502	83.9	135.918	137.285	134.668
54	1547	87.1	141.102	142.469	139.852
55	1702	92.1	149.202	150.569	147.952
56	1802	96.0	155.520	156.889	154.270
57	1902	100.6	162.972	164.339	161.722
58	2002	105.4	170.748	172.115	169.498
59	2102	110.5	179.010	180.377	177.760
60	2202	115.7	187.434	188.801	186.184
61	2302	120.6	195.372	196.739	194.122
62	0002	125.5	203.310	204.677	202.060
63	0102	131.6	213.192	214.559	211.942
64	0202	136.3	220.806	222.173	219.556
65	0302	141.2	228.744	230.111	227.494
66	0402	146.4	237.168	238.535	235.918
67	0502	151.0	244.620	245.987	243.370
68	0602	156.0	252.720	254.087	251.470
69	0702	160.8	260.496	261.863	259.246
70	0802	165.5	268.110	269.477	266.860
71	0847	168.8	273.456	274.823	272.206
72	0902	169.8	275.076	276.443	273.820

C_S = 1.62 Ky/sec
SR = 1.367 Ky
R_{SP} = 2.617Ky

Shot 4000 feet
Proj 4000 feet
Proj 7851 ft behind shot
Shot travels 4100 ft before detection

TABLE 11
STATION 6 RUN 1

ITEM	TIME	T/T	$T.C_S$	R_S	R_P
1	1708	1.0	1.620	1.651	1.530
2	1720	1.2	1.944	1.975	1.854
3	1745	3.9	6.318	6.349	6.228
4	1800	6.0	9.720	9.751	9.630
5	1815	8.0	12.960	12.991	12.870
6	1830	9.9	16.038	16.069	15.948
7	1845	11.5	18.630	18.661	18.540
8	1900	14.0	22.680	22.711	22.590
9	1915	16.0	25.920	25.951	25.830
10	1930	18.1	29.322	29.353	29.232
11	1945	20.4	33.048	33.079	32.958
12	2000	22.3	36.126	36.157	36.036

C_S = 1.62 Ky/sec
SR = .031 Ky
Rsp = .121 Ky

Shot 60 ft
Proj 60 ft
Project 364 ft aft of shot
Shot travels 93 ft before detection

TABLE 12
STATION 6 RUN 2

ITEM	TIME	T/T	T/cs	R_s
1	2330	19.4	31.428	31.459
2	2340	17.7	28.674	28.705
4	2350	16.4	26.568	26.599
5	2355	15.8	25.596	25.627
6	0000	14.8	23.976	24.007
7	0005	14.2	23.004	23.035
8	0010	13.4	21.708	21.739
9	0015	12.6	20.412	20.443
10	0020	11.6	18.792	18.823
11	0025	11.2	18.144	18.175
12	0030	10.4	16.848	16.879
13	0035	9.6	15.552	15.583
14	0040	9.2	14.904	14.935
15	0045	8.2	13.284	13.315
16	0050	7.4	11.988	12.019
18	0056	6.6	10.692	10.723
19	0100	6.1	9.882	9.913
20	0105	5.2	8.424	8.455
21	0110	4.5	7.290	7.321
22	0115	3.9	6.318	6.349
23	0120	3.3	5.346	5.377
24	0125	2.9	4.698	4.729
25	0130	2.7	4.374	4.405

C_s = 1.62
SR = .031

Shot 60 ft
Shots only
Shot travels 93 ft before detection

TABLE 13
STATION 7 RUN 1

ITEM	TIME	T/T	$T.C_s$	R_s	R_p
1	0309	.3	.486	.839	.705
2	0316	1.05	1.701	2.054	1.920
3	0336	4.2	6.804	7.157	7.023
4	0351	6.8	11.016	11.369	11.235
5	0401	8.4	13.608	13.961	13.827
6	0416	11.0	17.820	18.172	18.039
7	0431	13.6	22.082	22.385	22.251
8	0446	16.2	26.244	26.597	26.463
9	0501	18.75	30.375	30.728	30.594
10	0521	22.1	35.802	36.155	36.021
12	0546	26.29	42.590	42.943	42.809
13	0601	29.9	49.438	48.791	48.657
14	0616	31.3	50.706	51.059	50.925
15	0631	33.8	54.756	55.109	54.975
16	0651	37.4	60.588	60.941	60.807
17	0701	39.0	63.180	63.533	63.399
18	0716	41.5	67.230	67.583	67.449

C_s = 1.62 ky/sec
SR = .3527 ky
R_{sp} = .1333 ky

Shot 200 feet
Proj 200 feet
Proj 400 ft aft of shot
Shot travels 1058 feet before detection

TABLE 14
STATION 7 RUN 2

ITEM	TIME	T/T	C_s.T	R_s	R_p
1	1231	47.8	77.436	77.789	77.922
2	1301	43.5	70.470	70.823	70.956
3	1331	39.4	63.828	64.181	64.314
4	1401	35.3	57.186	57.539	57.672
5	1436	30.4	49.248	49.601	49.734
	1530	22.4			36.288
	1600	18.4			29.808
	1630	14.2			23.004
	1700	9.4			15.228
	1730	4.5			7.290
	1800	.8			1.296

C_s = 1.62 ky/sec
SR = .3527 ky
R_{sp}= .1333 ky

Shot 200 feet
Proj 200 feet
Proj 400 ft aft of shot
Shot travels 1058 feet before detection